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Flexible Elastoresistive Tactile Sensor for Minimally Invasive Surgery

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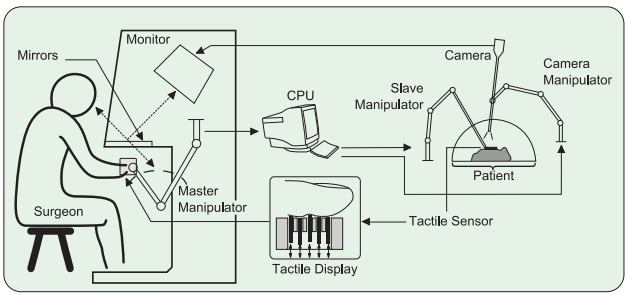
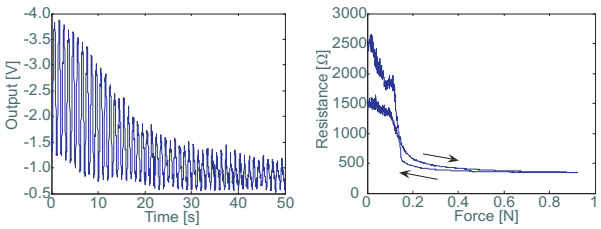
Abstract

In minimally invasive surgery, tactile feedback is lacking. An elastoresistive tactile sensor is designed to feel inside the body of the patient. The sensor is thin, flexible, robust, cheap, and has a simple structure. It has 16x16 elements, a spatial resolution of 1 mm and a bandwidth of 78 Hz. Despite a large hysteresis and non-linear behaviour, the sensor is very well suited for a qualitative measurement of the pressure distribution, with a high resolution in position, force and time.



In minimally invasive surgery, the surgeon operates a master manipulator at a separate console. His movement is copied by the slave manipulators inside the patient. The goal of this research is to attach the tactile sensor to a slave manipulator and feed back the tactile image to the surgeon.



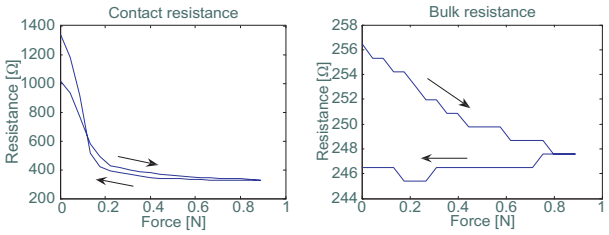
Nonlinear effects. Right: serious signal degradation, to be avoided in the selection of elastoresistive rubbers. Left: force-resistance hysteresis

Elastoresistance

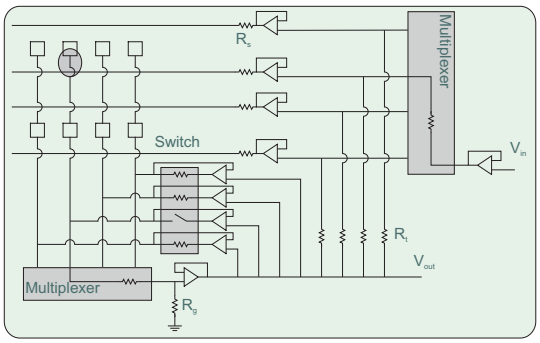
- Rubber matrix filled with conductive particles
- Electrical resistance changes under pressure

Advantages:
- sensitivity to low forces
- easy to miniaturise
- easy readout
- high bandwidth possible
- robust
- absence of excessive currents or voltages

Disadvantages:
- highly nonlinear
- hysteresis
- creep
- signal degradation



Comparison between the change in bulk resistance and the change in contact resistance. The contact resistance between rubber and electrode is responsible for the elastoresistive effect.

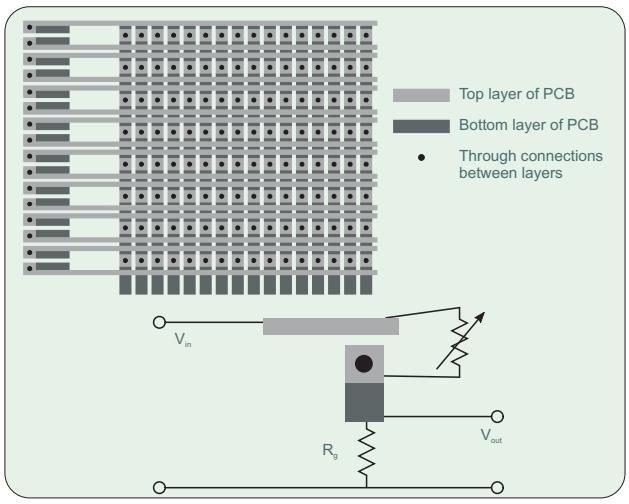


Readout electronics for the tactile sensor, with compensation circuits to avoid crosstalk

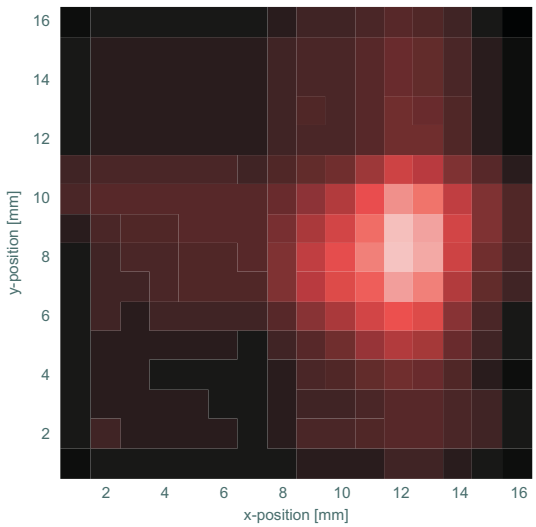
Tactile Sensor

- Flexible PCB with electrodes
- Conductive rubber
- Isolating layer

→ The sensor is very thin, cheap and flexible and can be applied to a curved surface, such as a finger shaped probe.



Matrix structure and working principle of the sensor electrodes on the PCB-layout. A taxel is located between a line (row) and a square (column).



To demonstrate the relevance of the tactile sensor in minimally invasive surgery, the sensor is used to find a simulated tumour. It is no problem to find a hard ball inside a soft tissue phantom.

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